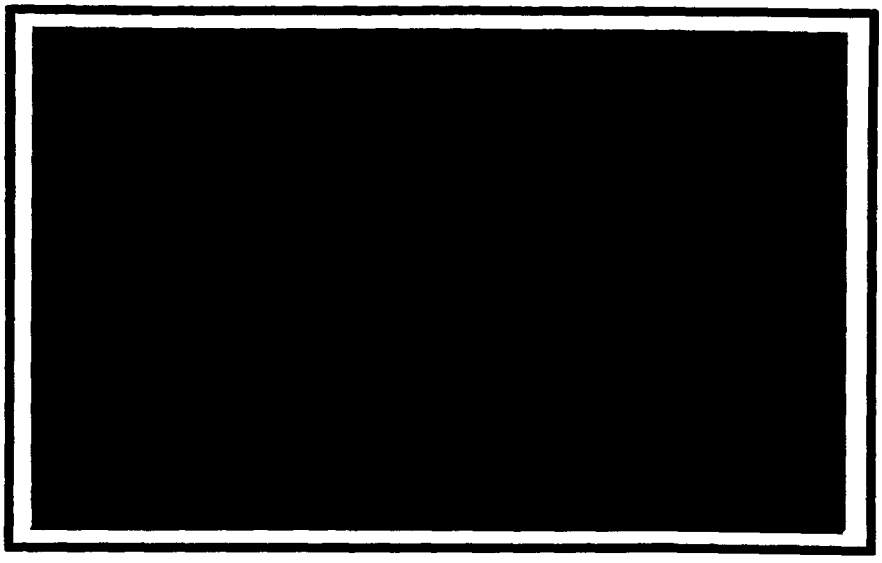

DEPARTMENT OF ELECTRICAL ENGINEERING

UNIVERSITY OF UTAH

SALT LAKE CITY, UTAH

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SEMIANNUAL STATUS REPORT NO. 3

INVESTIGATION OF METEOROLOGICAL MEASUREMENT TECHNIQUES UP TO 100 KILOMETERS

Third Semiannual Report Under
Grant NGR-45-003-025

For the period
1 October 1966 - 31 March 1967

University of Utah
Electrical Engineering Department

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Principal Investigator

April 26, 1967

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RESEARCH PERFORMED DURING REPORTING PERIOD

Work under the grant has continued in the areas enumerated in the previous semiannual report, viz:

a. Formulation of the mathematical model of the meteorological rocketsonde temperature sensors.

b. Derivation and compilation of quantitative data, including variabilities, of associated environmental parameters.

c. Study of radiation shields for temperature sensors.

d. Development of a numerical technique for the calculation of the thermal behavior of a planar film.

e. Study of noise in the radar data from the falling sphere technique.

f. Evaluation of the pitot-static pressure measuring technique.

In addition, research was initiated toward improvements in the operational rocket meteorological data handling system. The results of the research are being organized into a series of technical reports, the first number of which was submitted to NASA as a progress report in March, 1967. This first report presented a quasi-equilibrium model which mathematically represents very well the current generation of film-mounted rocketsonde thermistors. It shows that in the mesosphere the film rather than the bead is the sensor of the air temperature and that the film at these altitudes forces the bead temperature. The film, when not encumbered with the thermal mass associated with the presence

of the bead, has a much better time constant.

The quasi-equilibrium model lends considerable insight into the behavior of the bead-wire-film sensor system and facilitates comparative analysis and evaluation. An inverse form of the model is the basis of new temperature correction formulae derived for use on rocketsonde flight data. An automatic data processing program using these formulae is being developed which will receive digital data recorded from the tracking radar and temperature data from the rocketsonde transmitter and will produce corrected wind and temperature profiles. Initial experiments with this program at Wallops Station are expected this spring.

Functional expressions for the convection coefficients and recovery factor for beads, wires, and films, together with quantitative data regarding the associated variability and uncertainty, have been compiled. These quantities are essential to the determination of the altitude capability of immersion temperature sensors and are necessary for accurate correction calculations. The computer subroutine developed for calculating these quantities for the flow conditions at given altitudes and air speeds is being used to generate tables for general reference. The tables will be included, along with a discussion of the subroutine and its mathematical-empirical bases, in a report planned for submission by June, 1967.

A parallel report will treat the thermal radiation problem associated with rocketsonde sensors. A radiation model will be presented

with calculations and numerical values of interest relative to current sensors. At higher altitudes decreased convective coupling of the sensor to the air allows radiation errors to become large. Careful evaluation of the radiative heat transfer process is, therefore, necessary to properly correct flight data, and to evaluate altitude capability.

With the possibility that radiation correction uncertainity may be reduced with the use of a radiation shield around the sensor, a study was performed to determine the maximum distance (the entry length) into a tube that a sensor may be placed without encountering the thermal boundary layer inside the tube. The results of this study including the effects of a rarefied flow are presented in a report being reviewed for submission.

Final improvements in the computer subroutine for the solution of the two-dimensional time-dependent temperature distribution over an heterogeneous flat plate under a convective and radiative environment are being made. A report describing the program and giving the results of test cases, together with its application to the ARCASONDE 1A sensor, will be submitted by early summer.

A paper "Theoretical Comparison of Beads, Wires, and Films as Rocketsonde Temperature Sensors in the Mesosphere" is scheduled for presentation at the National Meeting of the American Meteorological Society in Los Angeles on June 20, 1967. The paper will be taken from a technical report under this grant which, in turn, will draw from the

above reports to show the relative merits of the three basic sensor shapes and make recommendations for future sensor developments. Proposed sensor concepts will be discussed including the "film shield film sensor" concept and the "total temperature sensor" concept, both of which have arisen in the course of the research.

Digital programs and procedures were developed to extract the range resolver error (a cyclic radar error) from falling sphere radar data. This error has been successfully evaluated and subtracted from radar data obtained from Sandia Corporation of flights recorded at Kauai, Hawaii last summer. The procedure is being applied to other sphere radar records and a report is expected by June. The noise remaining after subtracting the range resolver error and the sphere motion (the smooth drag-free motion near apogee) is under study to determine whether other predictable components can be identified and evaluated and to determine statistical characteristics which might be simulated or used in evaluating the accuracy of the falling sphere technique.

Study of the pitot-static technique for rocket-borne measurement of atmospheric pressure will be accelerated in the next period. Sandia Corporation has conducted field experiments involving simultaneous use of the pitot-static probes and the falling sphere and is beginning to report results. It is hoped that cooperative effort and exchange of data will produce evaluations of mutual benefit.

The applicability of the research under this grant to atmospheric measurements on other planets is being studied. In situ measurements

in the sensible atmosphere of Mars and Venus likely will be a necessary complement and verification to early remote sensing experiments.

The quality of operational measurements from current rocketsonde systems can be improved not only through better sensors and through automatic data processing, but also through a better air-to-ground data link. A miniature module is being designed and constructed which will be attached to an ARCASONDE 1A payload to demonstrate the potential operational merits of a pulse code modulated signal from the parachute-borne transmitter. Since the experimental modification will not interferewith the normal operation of the overall system, the benefits of the digitized channel may be readily assessed by comparison of its output with that of the conventional data channel. Completion of design, construction, and ground tests of demonstration units are expected by midsummer. Requests for flight test will be submitted when and if conditions warrant.

It is expected that the research for at least three academic theses will be completed this summer. The pulse code modulator experment and the sphere data processing investigation are presently being pursued as thesis subjects. Others are being considered.

Travel during the six month period included the following:

1. El Paso, Texas, 7-11 November 1966; to attend the American Meteorological Society Conference on the Dynamic Structure of the Free Atmosphere, and for technical discussion with Dr. K. J. Touryan of Sandia Corporation concerning the

performance of pitot-static probes for the measurement of atmospheric pressure.

2. New York City and Langley Research Center, Virginia, 23-28 January 1967; to attend American Institute of Aeronautics and Astronautics Fifth Aerospace Science Meeting and 47th Annual Meeting of the American Meteorological Society, and for conference with the NASA technical personnel associated with this research grant.

3. Houston, Texas, 27-31 March 1967; to present a paper based on the work under this grant, "Mathematical Model of the Film-Mounted Rocketsonde Thermistor," at the American Meteorological Society Conference on High Altitude Meteorology and Space Weather."

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